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Study the Effect of Silica Nanoparticle Assisted Lubricant –An Overview

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Abstract - *This paper to investigate the tribological behaviour of silica nanoparticle added in lubricant. Study the effect of silica nanoparticle under different load, speed, concentrations and check the adaptability of nanopartcles with fluid. Wear scar diameter increases with increasing load but coefficient of friction decreases. Silica nanoaparticle has many advantages as compared to other nanoparticle.*

***Key Words*: silica nanoparticle, wear scar diameter, co-efficient of friction.**

1. INTRODUCTION

In the past few decades, rapid advances in nanotechnology have led to emerging of new generation of coolants, this is called "nanofluids". Nanofluids are a relatively new class of fluids which consist of a base fluid with nano-sized particles suspended within them. These nanoparticles, generally a metal or metal oxide, which increase conduction and convection coefficients, allowing for more heat transfer out of the coolant. Nanofluids enhances the thermophysical properties such as thermal conductivity, thermal diffusivity, viscosity, convective heat transfer coefficient.[1] Metal oxides plays a very important role in many fields such as chemistry, physics and materials science. There are many technical application of metal oxide like in fabrication of microelectronics circuits, sensors, piezoelectric devices, fuel cells, coatings for the passivation of surfaces against corrosion and as a catalysis. Oxide nano-particles can exhibit unique physical and chemical properties due to their limited size and a high density of corner or edge surface sites e.g. TiO_2, Al_2O_3, CuO, SiO_2, Au, Ag, Fe naopartcles.

SiO_2 has been intensive research due to its outstanding chemical and physical properties. It exist in many crystalline forms such as quartz, crystoballite, tridymite and coesite but its well known form is amorphous silicon dioxide[2]. Silica nanoparticle occupy a important place in scientific research due to their easy preparation and their specific chemical and physical properties, and various uses in many industrial application such as in pharmacy, as catalysis, pigments, sensors etc.[1]

Silicon was first isolated and described by a Swedish chemist, Jacob Berzelius in 1824, as an element. An impure form of silica was obtained in 1811. Crystal form of silica was first produced by electrolysis in 1854[3].

Silicon is found in nature in various form. Mostly form are found in oxide not as nascent, it is always present in combination with oxygen because oxide form is most suitable form, it does not react with environment. 78% of earth 's crust consists of silicon and oxygen compounds, both amorphous and crystalline compounds. Silica is also found in ocean as silicic acid in dissolved form. Silica is also founds in living organisms like grasses, sponges, algae etc[4].

In modern machinery system its very difficult to the proper functioning of machines as there is the critical to reduce friction and wear. A more complex machines has stricter lubricants requirements [5]. To withstand at high temperature and extreme pressure of machines component and mechanisms pairs, a high quality of lubricants is require. For improving the tribological behaviour of lubricant, extreme pressure and antiwear additives are used in reducing friction and surface damage under given working conditions.

Silica nanoparticles provide better wear resistance, friction reduction, oxidation inhibition and thermal conductivity, than other nanoparticles. Silica nanoparticle is very cheap and easily available. Sulphur, chlorine, phosphorous containing compounds as traditional additives are designed to cover chemical metal surface by forming easily sheared layers of sulphides, chlorines or phosphides, preventing severe wear and seizure. However, for environmental reasons, the use of chlorine and phosphorus containing compounds has been and should be restricted. Therefore, many researchers have sought new additives for lubricant for use under severe conditions to reduce pollution [5].

2. Parameters effecting silica nanoparticle-

2.1 Under different load- When silica is added to the base oil under different load condition the coefficient of friction is reduces. This effect could be due to the rolling of sphere like nanoparticle between the rubbing surface. Wear scar diameter is increases.

Qiang He and co-workers shows the effect of nanometer SiO_2 on the frictional behaviour of lubricating grease[6]. SiO_2 nanoparticle are capable of performing better friction reducing performance and anti wear capacity than base grease at all loads.

Meena Laad and co-workers shows Titanium oxide nanoparticle as additives in engine[7]. It observed that the wear rate to be increasing with the load for lubricating oil without TiO_2 nanoparticle as well a with TiO_2 nanoparticle as additive.

2.2 Concentration

Silica nanoparticle reduce the wear scar diameter of steel ball and coefficient of friction is also reduces. Wear scar diameter varies with the proportion of the nanoparticle added above 0.025%. This indicates that liquid paraffin can reduce the wear scar diameter of steel ball than pure liquid paraffin[5].

D.X. Peng and co- workers shows the Tribological behaviour on silica and diamond nanoparticle added in paraffin[5]. Liquid paraffin contain diamond and silica can reduce the wear scar diameter of steel ball more than can pure liquid paraffin. The friction of co-efficient are measured by performing sliding tests with pure liquid paraffin with 0.2 wt % diamond and liquid paraffin with 0.2 wt % silica nanoparticle.

At the beginning the coefficient of friction of liquid same as that with pure liquid paraffin. Silica nanoparticle with low concentration is very low and stable as compared to diamond.

D. X. Peng and co-workers shows the size effect of SiO_2 nanoparticle as oil additiv[8]. Coefficient of friction is markedly reduces as small silica nanparticle are added to the liquid paraffin. As the concentration rises coefficient of friction increases slowly. In terms of wear scar diameter, addition of small amount of silica nanoparticle to liquid paraffin can reduce the diameter of wear scar on a steel ball that in pure liquid.

Da Jiao and co-workers shows the tribological properties of alumina/silica composite nanoparticle as lubricant additive[9]. When optimized concentration of nanoaparticle additive is small the wear scar diameter and coefficient of friction are both smallest.

2.3 Rotational speed

M.A. Fazal and co-workers shows investigation of friction of wear characteristics of palm biodiesel[10]. When silica nanoparticle is added to base oil under rotational speed coefficient of friction varies linearly and wear scar diameter increases with increasing the rotating speed. Lubricity in terms of wear and friction decreases with the increase of rotating speed.

2.4 Adaptability of silica nanoparticle with base oil

It is generally known that nanoparticles as the ultrafine particles possess many advantages, such as surface effects, quantum size effect, and so on. Therefore, the nanoparticles are so small that they can easily adsorb or deposit on the blemish surface. When the nano-SiO_2 is added into the base oil, they can be easily transferred into the metallic surface and even the worn area of tribo-pairs during the frictional process [6]. Silica nanoparticle exhibiting unique properties such as immiscible in both oil and water an extremely large surface area and exhibited excellent catalyst activity[2].

3. Silica nanoparticle used

3.1 Spherical shape

Silica nanoparticle are mostly used in various industries and field because of its spherical shape and size. Mesoporous silica nanoparticle have recently attracted much attention in the various field due to their unique characteristics, including a high BET surface area, large pore volume and uniform porosity. Spherical silica nanoparticle is excellent candidate for development of drug delivery systems.[11]

The shape of nanoparticles used in lubricant additives is another important parameter to consider in the context of designing nanoparticle-based lubricants. The shape of the nanoparticles directly determines the pressures experienced by nanoparticles upon loading. For instance, for a given load, nanospheres experience the largest pressure and nanosheets experience the smallest pressure, because while nanospheres make point contact with a counter surface, nanoplatelets make a planar contact (Figure 2). Thus, for a given load, nanosheets have the least chance of indenting and deforming the asperities of shearing surfaces[12].

3.2 Availability of silica nanoparticle

Silica nanoparticle are found in nature in various form. 78% silica nanoparticle are found on the earth's crust. It is the combination of oxygen and silica. Silica nanoparticle are very cheap so it is easily available.

4. Benefits of Silica nanoparticle to other nanoaparticle

The increasing area of engineered NPs in industrial and household applications leads to the release of such materials into the environment. Assessing the risk of these NPs in the environment requires on understanding of their mobility, reactivity, eco toxicity and persistency. The engineering material applications can increase the concentration of NPs in groundwater and soil which presents the most significant exposure avenues for assessing environmental risks.[13]

SiO_2 nanoparticles have particular physical, chemical, and optical properties that have led to its wide use in many fields. They are used as functional materials, catalyst, plastics, rubbers paints, biomedicine, and semiconductive material. High-quality SiO_2 nanoparticles cannot be produced by conventional methods. SiO_2 particles have many advantages, including narrow size distribution and desirable characteristics, such as very small size, high chemical purity, and high chemical homogeneity [14].

SiO_2 NPs possess excellent mechanical properties in terms of hardness, thermal stability and large surface area. Besides,

SiO_2 NPs are cheap, available on the market, and high quality[15].

There are many benefits of silica nanoparticle as compared to other nanoparticle as silica nanoparticle is-

- Non toxic
- Non flammable
- Chemically un-reactive and insoluble in water
- Eco-friendly with environment
- Reduces energy consumption

5. Conclusion from research overview

From the overview of literature available on silica nanoparticle it was found that many researchers have tried to study the effect of silica nanoparticle assisted lubricant by taking into consideration various parameters. The conclusions that can be drawn by conducting the literature overviews as follows-

- The SiO_2 nanoparticle dispersivity and stability are better than those of nanodiamond in liquid paraffin.
- The SiO_2 nanoparticles are not only cheap and easily obtained but also exhibit the same excellent tribological behaviors as compare to the other nanoparticles.
- This research overview shows that small size of silica nanoparticle as an additive have excellent load carrying capacity and good tribological behaviours.
- The silica nanoparticle not only bear the load but also separate the surface dominting the reduction in wear and friction.
- From the literature survey mostly used silica nanoparticle is spherical silica nanoparticle because of their unique shape and size, and properties.

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